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Effect of Chitosan and Nitrogen Rates on Growth and Productivity of Summer Squash Plants

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ABSTRACT

This experiment was carried out during two successive summer seasons of 2012/2013 and 2013/2014 at El-Khattara Experimental Farm, Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt, to study the effect of nitrogen fertilization and foliar spray with chitosan on growth, yield and fruits quality of summer squash plants grown in sandy soil. This experiment included nine treatments which were the combinations between three rates of nitrogen (45,60 and 75kg/feddan) and three concentrations of chitosan (0.0 , 0.05 and 0.10g/l). The results revealed that the fertilization of summer squash plants with N at 75 kg/feddan significantly enhanced plant growth characters, yield and its components, and nutrients (N, Fe, Cu, Mn and B). While, T.S.S.(%), P and K contents in fruits were not significantly affected. Moreover, spraying with chitosan at 0.10g/l significantly increased plant growth characters, yield and its components, T.S.S.%, N and P. On the other hand, it decreased Fe, Zn, Cu and B content in fruits. In addition, the interaction treatments between N at 75 kg/feddan and spraying plants with chitosan at 0.10g/l gave the highest values of plant growth, yield and its components, N as well as P content in summer squash fruits.

Key words: Summer squash, nitrogen, chitosan, growth and yield.

Introduction

Squash (*Cucurbita pepo* L.) is a very popular crop grown in different regions of Egypt. It is a member of the Cucurbitaceae family which is supplying humans with edible products and useful fibers. Also, squash is one of the most important cash crops, especially, in newly reclaimed areas of Egypt.

Nitrogen is an essential nutrient for crop production and important for plant growth. It constitutes about 1.5 - 6% of the dry weight of many crops (Sanjuan *et al*., 2003). It also plays a role in chlorophyll synthesis and hence the process of photosynthesis (Jasso-Chaverria *et al*., 2005).

Nitrogen deficiency exhibit stunted growth and small leaves, while excess nitrogen induce lush plants with soft tissues and lateness in maturity (Wolf,1999). In this respect, plant height, stem diameter, number of leaves, leaf area and leaf area index and yield of zucchini plant were significantly affected by nitrogen compared to the control (Ng'etich *et al*., 2013).

Chitosan is a natural biopolymer, which can be extracted from the marine crustacean or from the exoskeletons of insects under the name of chitin which can be transformed into chitosan by extracting the acetyl group and turn it into amino (Sugiyama *et al*.,2001).

Becker *et al*. (2000) reported that chitosan contains nitrogen in the basic unit of its formula. When the nitrogen contained in the chitosan is dissolved, it penetrates gradually and remains in the soil for a long period of time. It was reported that chitosan improved the transportation of nitrogen in the functional leaves which enhanced plant growth and development (Chibu and Shibayama, 2003; Gornik *et al*.,2008). In addition, chitosan led to a strong increase in extracellular peroxidase activity (Ortmann and Moerschbacher, 2006).

Many investigators reported that using chitosan as foliar spray increased vegetative growth, yield and quality of vegetable crops including cucumber (Farouk *et al*., 2008), strawberry(Abdel-Mawgoud *et al*.,2010), sweet pepper (Ghoname *et al*.,2010), cowpea (El-Tanahy *et al*.,2012), garlic (Fawzy *et al*., 2012), okra (Mondal *et al*., 2012), cucumber (Shehata *et al*., 2012) and mung bean (Mondal *et al*., 2013).

Sheikha and AL-Malki (2011) found that chitosan can be also used as a treatment for mineral contaminated soil. In addition, chitosan is not only decreasing pollution, but also nourishing the plant and decrease coasts too (Delphine *et al*., 2005).

Therefore, the aim of this study is to improve the productivity and quality of summer squash plants by using different rates of mineral nitrogen fertilizer with foliar spray of chitosan.

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Materials and Methods

This experiment was carried out during two successive summer seasons of 2012/2013 and 2013/2014 at El-Khattara Experimental Farm, Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt, to study the effect of foliar spray with different chitosan concentrations and nitrogen fertilizer rates on growth, yield and fruit quality of summer squash. The experimental soil was sandy in texture with drip irrigation system. The soil chemical properties were: organic matter 0.07 and 0.09%; available N 14.62 and 14.98(ppm); available P 18.0 and 19.46 (ppm); available K 59.6 and 63.1(ppm); pH 7.90 and 7.88 and E.C. 2.10 and 2.50 mmhos/cm in the first and second seasons, respectively.

This experiment included nine treatments which were the combinations of three nitrogen rates (45, 60 and 75 kg/feddan) and three concentrations of chitosan(0.0 ,0.05 and 0.10g/l). These treatments were arranged in a split plot design with three replicates. Nitrogen fertilizer rates were randomly arranged in the main plots and the concentrations of chitosan were randomly distributed in the sub plots. Each experimental plot area (18 m²) consisted of three dripper lines with 6 m length and 1.0 m between each two dripper lines. Seeds of squash (*Cucurbita pepo* L. cv. Eskandarani) were sown on 1st of may on one side of drippers line on hills at 30 cm between hills in both seasons.

The plants were sprayed by different concentrations of chitosan at three times with 10 days interval between them, started from 25 days after sowing. Untreated plants (0.0 g/l) were sprayed with tap water.

The quantity of nitrogen fertilizer of each rate were divided into five equal portions. The source of mineral-N fertilizer was ammonium sulphate (20.5%N). In addition, calcium superphosphate (16-18% P_2O_5) fertilizer was added at a rate of 300 kg/feddan, half of the amount was added during soil preparation with botanical compost (at a rate of 30m^3/feddan), the rest amount of phosphate fertilizer and 150 kg potassium sulphate (48-52% K_2O) were divided into seven equal portions and added to each plot after sowing. The normal agricultural practices such as irrigation, weeding and pest control were carried out during the growing season as recommended

Date recorded:

Plant growth characters:

A random sample of three plants from each plot unit were taken at 50 days after sowing to investigate the following growth parameters: plant height (cm), number of leaves per plant and leaf area (cm^2)/plant. After that, different plant parts were oven dried at 70°C till constant weight, then total dry weight/plant (g) was recorded. LA was estimated by the following formula: Leaf area/plant (cm^2) = Leaves dry weight per plant (g) x disk area (cm^2)/ disk dry weight (g).

Yield and its components:

Squash fruits at marketable stage were harvested twice every week. At the time of harvesting, fruit diameter (cm), fruit length (cm), average fruit weight (g) and total yield (Ton/feddan) were recorded.

Fruit quality:

Fruits from the second harvest were dried till constant weight. It was finely grinded and digested. After that nitrogen, phosphorus and potassium percentages were determined (on dry weight basis) according to the methods by Bremner and Mulvaney (1982), Olsen and Sommers (1982), and Jackson (1970),respectively. Micro nutrients (Fe, Cu, Zn, Mn and B) were determined using Atomic Absorption Spectroscopy (AAS) according to Chapman and Pratt (1982). In addition, total soluble solids were determined in fruit juice by Carle Zeis Refractmeter.

Statistical analysis:

All the obtained data were statistically analysis using the COSTAT program and means separation were done by least significant value (L.S.D.) at 0.05 level of probability according to Snedecor and Cochran (1980).

Results and Discussion

Plant growth

Effect of nitrogen rates

Data in Table 1 show the effect of nitrogen rates on the plant growth characters of summer squash (at 50 days after sowing) during the two seasons of study (2012/2013 and 2013/2014). It is

obvious from such data that summer squash plants growth characters of significantly increased with increasing nitrogen rates.

Application of 75 kg N/feddan recorded the higher values among all growth characters except for plant height and number of leaves per plant which have no significant differences between the two rates 60 and 75 kg/feddan in both seasons.

The stimulative effect of nitrogen on growth characters may be due to the major role of nitrogen on protein and nucleic acids synthesis and protoplasm formation. That's in role induce cell division and initiate meristematic activity for producing more tissues and organs. Thus, plant growth could be effected by nitrogen amount (Marschner, 1995; Najm *et al*., 2012). Also, it could be attributed to increase the uptake of nitrogen and its associated role in chlorophyll synthesis which in role hence the process of photosynthesis and carbon dioxide assimilation (Jasso- Chaverria *et al*., 2005).

These results agreed with those reported by Demir *et al*. (1996) on spinach, Gabr *et al*.(2001) on sweet pepper, Abdel-Mawgoud *et al*.(2005) on snap bean, Ghoneim (2005) on sweet pepper, Ahmed *et al*.(2007) on cucumber, Boroujerdnia and Ansari(2007) on lettuce, Sincik *et al*.(2008) on potato, Ngʹetich *et al*.(2013) on zucchini and Shaheen *et al*.(2014) on potatoes. They all concluded that an increase in nitrogen application increased significantly vegetative growth characters.

Table 1: Effect of nitrogen rates and chitosan on morphological characters of summer squash plants (at 50 days after planting) during 2012/2013and 2013/2014 seasons.

	First season				Second season			
Treatments	Plant height (cm)	Number of leaves per plant	Total dry weight per plant (g)	Leaf area (cm^2)	Plant height (cm)	Number of leaves per plant	Total dry weight per plant (g)	Leaf area (cm^2)
N rates (kg/feddan)								
45	61.91 b	20.16 b	60.03 c	5939 c	59.83 b	19.25 b	58.11 c	6220 c
60	73.38 a	24.91 a	76.27 b	8307 b	74.25 a	26.44 a	80.57 b	9687 b
75	74.83 a	24.86 a	87.00 a	10269 a	75.83 a	25.25 a	91.97 a	11809 a
Chitosan (g/l.)								
0 .00	65.33 c	18.83 c	48.51 c	5101c	66.50 b	16.91 b	53.43 c	6943 c
0.05	69.97 b	23.00 b	72.45 b	8347 b	69.75 ab	25.66 a	73.89 b	9318 b
0.10	74.83 a	28.11 a	102.33 a	11068 a	73.66 a	28.36 a	103.32 a	11454 a

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability.

Effect of chitosan

Results in Table 1 show that the foliar spray with chitosan increased plant height, number of leaves, total dry weight and leaf area/plant of summer squash plants as compared to the control (untreated).The best treatment which gave the highest significant values was 0.10g/l chitosan with no significant differences with chitosan at 0.05g/l with respect to plant height and number of leaves/plant in the second season.

The significant effect of chitosan on plant growth may be attributed to an increase in the key enzyme activities of nitrogen metabolism (nitrate reductase, glutamine synthetase and protease) and increased photosynthesis which enhanced the plant growth (Gornik *et al*., 2008; Mondal *et al*.,2012). In addition, chitosan induce to synthesize plant hormones such as gibberellins. Furthermore, it enhances growth by some signalling pathways related to auxin biosynthesis via a tryptophan-independent pathway (Uthairatanakij *et al*.,2007; El-Bassiony *et al*.,2014). Also, may be attributed to an increase in the availability and uptake of water and essential nutrients through adjusting cell osmotic pressure, and reducing the accumulation of harmful free radicals by increasing antioxidants and enzyme activities (Guan *et al*., 2009).

The enhancement of summer squash growth characters by foliar application of chitosan are in accordance with those found by Farouk *et al*.(2008) on cucumber, El-Tantawy(2009) on tomato, Abdel-Mawgoud *et al*.(2010) on strawberry, Ghoname *et al*.(2010) on sweet pepper, Farouk *et al*.(2011) on radish, Sheikha and AL-Malki(2011) on bean, El-Tanahy *et al*.(2012) on cowpea, Fawzy *et al*.(2012) on garlic, El-Miniawy *et al*.(2013) on strawberry and Mondal *et al*.(2013) on mung bean. On cucumber, Shehata *et al*.,2012 found that foliar application of chitosan at rate of 4ml/l was recorded the highest vegetative growth. Furthermore, Mondal *et al*.(2012) found that, most of the morphological characters in okra were increased with increasing chitosan concentration up to 25 ppm. In addition, Abu-Muriefah (2013) reported that, foliar-applied chitosan, in particular 200 mg/l increased the common bean plant growth as compared to control plants.

Effect of the interaction

The interaction between different nitrogen rates and chitosan concentrations increased significantly all vegetative growth characteristics (plant height, number of leaves, total dry weight and leaf area/plant) of summer squash plants as compared to the control treatment (0.0 g/l) in both seasons (Table 2).

Fertilization with N at 75 kg/feddan and spraying plants with chitosan at 0.10g/l gave the highest values of plant height, number of leaves (in the first season), total dry weight and leaf area/plant in both seasons. On the other hand, there was no significant differences in the case of the interaction between N (60 kg/feddan) and chitosan (0.10g/l) with respect to plant height and number of leaves/plant in the first season. Furthermore, there were no significant differences in the interaction between N at 60 or 75 kg/ feddan and chitosan at 0.05 or 0.10g/l with respect to plant height in the second season. Also, there was no significant difference with the interaction between N at 75 kg/feddan with chitosan at 0.10g/l and N at 60 kg/ feddan with chitosan at 0.05 or 0.10g/l with respect to number of leaves in the second season. In addition, there was no significant difference with the interaction between N at 75 kg/ feddan with foliar applications of chitosan at 0.05 or 0.10g/l with respect to leaf area/ plant in the both seasons. While, the lowest value was obtained by using 45 kg N/ feddan and foliar spraying of water (control treatment)

In this respect, El-Tanahy *et al*.(2012) on cowpea and Shaheen *et al*.(2014) on potatoes came to similar results. They stated that the best effect on plant vegetative growth (plant height, number and dry weights of leaves and shoots) was obtained by using the highest concentration of chitosan (5%) with the application of the inorganic fertilizer.

Table 2: Effect of interaction between nitrogen rates and chitosan on morphological characters of summer squash plants (at 50 days after planting) during 2012/2013 and 2013/2014 seasons.

Treatments		First season				Second season			
		Plant height (cm)	Number of leaves per plant	Total dry weight per plant (g)	Leaf area (cm^2)	Plant height(cm)	Number of leaves per plant	Total dry weight per plant (g)	Leaf area (cm^2)
N rates (kg/feddan)	Chitosan (g/l.)								
	0 .00	54.00 e	17.75 e	35.75 i	3366 f	57.00 e	14.50 d	37.07 f	4262 e
45	0.05	63.50 d	21.75 bcd	58.19 g	4815 ef	59.75 de	21.25 c	49.95 e	4754 e
	0.10	68.25 cd	21.00 cde	86.14 c	9638 cd	62.75 cde	22.00 c	87.30 c	9644 cd
	0 .00	70.25 c	18.25 de	46.20 h	5858 e	72.50 abc	15.25 d	54.07 e	7730 d
60	0.05	72.66 bc	25.00 b	76.97 e	8515 d	73.25 ab	30.50 ab	83.57 c	10810 bc
	0.10	77.25 ab	31.50 a	105.66 b	10550 bc	77.00 ab	33.58 a	104.07 b	10521 bc
	0 .00	71.75 bc	20.50 cde	63.60 f	6080 e	70.00 bcd	21.00 c	69.16 d	8838 cd
75	0.05	73.75 abc	22.25 bc	82.20 d	11711 ab	76.25 ab	25.25 bc	88.15 c	12391 ab
	0.10	79.00 a	31.83 a	115.20 a	13017 a	81.25 a	29.50 ab	118.59 a	14198 a

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability.

Yield and its components

Effect of nitrogen

Data presented in Table 3 show the effect of different nitrogen rates on yield and its components of summer squash during seasons of 2012/2013 and 2013/2014. It is obvious from such table that the application of nitrogen fertilizer at 75 kg/feddan reflected significant effect on yield and its components; i.e.,fruit length, fruit diameter, average fruit weight and total yield (Ton/feddan) during the two tested summer seasons.

The favourable effect of nitrogen on the yield may be increase the vegetative growth characteristics; i.e., plant height, number of leaves per plant, total dry weight per plant(g) and leaf area (Tables 1 and 2).

These results are in accordance with those obtained by Mishriky and Alphonse (1994) on pepper, Demir *et al*. (1996) on spinach,Shahin *et al*.(1999) on sweet pepper, Gabr *et al*. (2001) on sweet pepper,Gulser (2005) on spinach, Mahmoudi (2005) on lettuce, Harrelson *et al*. (2008) on pumpkins, Jilani *et al*. (2008) on brinjal, Marvi (2009) on lettuce and spinach, Ng′etich *et al*. (2013) on zucchini and Shaheen *et al*.(2014) on potatoes. They reported that there was attendant increase in the rate of nitrogen fertilizer with increasing the yield. Also, Ahmed *et al*. (2007) reported that an increase in nitrogen application resulted in maximum fruit length, fruit weight, and yield of cucumber.

Table 3: Effect of nitrogen rates and chitosan on yield and its components of summer squash during 2012/ 2013 and 2013/2014 seasons

Treatments	First season				Second season			
	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (gm.)	Total yield (Ton / feddan)	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (gm.)	Total yield (Ton / feddan)
N rates (kg/feddan)								
45	11.90 c	3.59 c	135.11 c	5.57 c	11.79 c	3.67 c	137.96 c	5.91 c
60	12.83 b	4.20 b	141.50 b	7.25 b	13.36 b	4.08 b	143.64 b	7.35 b
75	13.33 a	4.46 a	148.73 a	8.30 a	14.46 a	4.40 a	153.08 a	8.24 a
Chitosan (g/l.)								
0 .00	12.26 c	3.96 a	137.25 c	6.53 c	12.21 c	3.49 c	139.21 c	6.77 c
0.05	12.58 b	4.01 a	142.17 b	6.98 b	13.34 b	3.88 b	145.13 b	7.14 b
0.10	13.22 a	4.27 a	145.93 a	7.61 a	14.06 a	4.78 a	150.34 a	7.60 a

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability.

Effect of chitosan

Spraying with chitosan at 0.10g/l had significant effect on yield and its components; i.e., fruit length, fruit diameter, average fruit weight and total yield (Ton/feddan) in both seasons of study. While, the fruit diameter in the first season did not reflect any significant effect among the different chitosan concentrations (Table 3). The significant effect of chitosan on yield and its components might be due to chitosan have the simulative effect on physiological processes and improved the transportation of nitrogen in the functional leaves which improved vegetative growth and development (Chibu and Shibayama, 2003;Gornik *et al*.,2008).

These results are agreeable with those reported by Mondal *et al*. (2012) on okra, Shehata *et al*.(2012) on cucumber, Abu-Muriefah (2013) on common bean and El-Miniawy *et al*.(2013) on strawberry.

Effect of the interaction

Data presented in Table 4 show the effect of interaction between levels of nitrogen and spraying chitosan on yield and its components of summer squash during seasons of 2012/2013 and 2013/2014. It is interest to note that application of mineral nitrogen at the rate of 75 kg/feddan with chitosan at the rate of 0.10g/l to summer squash plants was the best interaction treatment which had significant effect on fruit length, total yield (Ton/feddan) and average fruit weight (g) during the two tested summer seasons. While, there were no significant differences with the interaction between N at 75 kg/feddan and chitosan at 0.05 or 0.10g/l with respect to average fruit weight in the second season only. In addition, the fruit diameter did not reflect any significant effect between most of interaction treatments in the first season. The most favorable interaction treatments for enhancing fruit diameter in the second season were application of mineral N at the rate of 60 or 75 kg /feddan with chitosan at the rate of 0.10g/l.

Table 4: Effect of interaction between nitrogen rates and chitosan on yield and its components of summer squash during 2012/2013 and 2013/2014 seasons.

Treatments		First season				Second season			
		Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (gm.)	Total yield (Ton / feddan)	Fruit length (cm)	Fruit diameter (cm)	Average fruit weight (gm.)	Total yield (Ton / feddan)
N rates (kg/feddan)	Chitosan (g/l.)								
45	0 .00	11.50 e	3.39 c	128.90 h	4.90 g	10.00 e	3.14 f	130.25 g	5.50 f
	0.05	11.66 e	3.46 c	136.06 g	5.35 f	12.25 d	3.46 e	138.25 f	5.77 f
	0.10	12.54 d	3.92 bc	140.39 e	6.48 e	13.12 c	4.43 b	145.39 d	6.48 e
60	0 .00	12.62 cd	4.11 ab	138.25 f	6.80 e	13.25 c	3.55 de	138.60 f	6.94 d
	0.05	12.75 cd	4.23 ab	140.06 e	7.36 d	13.27 c	3.74 cd	141.65 e	7.48 c
	0.10	13.12 bc	4.27 ab	146.20 c	7.61 cd	13.58 c	4.96 a	150.69 b	7.64 c
75	0 .00	12.66 cd	4.40 ab	144.60 d	7.90 bc	13.38 c	3.80 c	148.80 c	7.88 bc
	0.05	13.33 b	4.36 ab	150.40 b	8.24 b	14.50 b	4.46 b	155.49 a	8.18 b
	0.10	14.00 a	4.62 a	151.20 a	8.76 a	15.50 a	4.96 a	154.95 a	8.68 a

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability.

These results are in agreement with those found by El-Tanahy *et al*.(2012) on cowpea and Shaheen *et al*.(2014) on potatoes. They indicated that the best effect on yield and its component was obtained by using the highest concentration of chitosan(5%) with the application of the inorganic fertilizer.

Fruit quality

Effect of nitrogen

Fertilization of summer squash plants with nitrogen at 45, 60 and 75 kg/ feddan had no significant effect on T.S.S.(%), P and K contents in fruits.While, application of mineral nitrogen at the rate of 75 kg/ feddan showed significant effect of N content in the fruits. Also,the contents of Fe, Cu, Mn and B contents in fruits increased with increasing N rates (Table 5).

Obtained results are in accordance with those reported by Shaheen *et al*.(2014) on potatoes.They found that increasing nitrogen rates application up to 150 N units/ feddan has a gradually and constant increase in nutritional values of plant; i.e., N, Fe, Mn and Cu.

Table 5: Effect of nitrogen rates and chitosan on fruit quality of summer squash plants during 2013/2014 season.

Treatments	T.S.S%	Macro nutrients (%)			Micro nutrients (ppm)				
		N	P	K	Fe	Zn	Cu	Mn	B
N rates (kg/feddan)									
45	3.88 a	2.82 c	0.33 a	2.71 a	59.63 b	39.43 a	9.58 b	83.83 c	37.49 b
60	4.16 a	2.99 b	0.34 a	2.75 a	60.13 a	35.15 c	9.48 b	86.21 b	37.02 c
75	4.33 a	3.38 a	0.36 a	2.74 a	60.19 a	38.81 b	10.64 a	93.06 a	38.48 a
Chitosan (g/l.)									
0 .00	3.83 b	2.80 b	0.30 b	2.65 a	62.53 a	39.40 a	10.35 a	87.81 b	37.79 a
0.05	4.00 b	2.93 b	0.34 b	2.85 a	59.91 b	36.92 b	10.27 a	84.08 c	37.67 b
0.10	4.55 a	3.46 a	0.40 a	2.71 a	57.51 c	37.07 b	9.07 b	91.21 a	37.54 c

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability.

Effect of chitosan

Application of chitosan at the rate of 0.10 g/l had significant effect on T.S.S.%, N and P contents. On the other hand, all chitosan treatments, in general, had no significant effect on K content in the fruits. It obvious from data recorded in Table 5 that some micro nutrients; i.e., Fe, Zn, Cu and B contents in fruits decreased with increasing chitosan rates. The highest used concentrations of chitosan reduce some micro nutrients concentrations in fruits as compared to control(0.0 g/l.)

The significant effect of foliar spray of chitosan might be due to that chitosan is a new plant growth promoter such as GA_3 that may be have effect on the plant growth and yield (El-Bassiony *et al*.,2014) .On the other hand, for the effect of foliar spray of chitosan on macro and micro nutrients (N, P, K, Fe, Zn, Cu and B), chitosan can be used as a treatment for mineral elements contaminated soil (Sheikha and AL-Malki.,2011).

Similar results were also obtained by Farouk *et al*.(2008) on cucumber, Ghoname *et al*.(2010) on sweet pepper, Abu-Muriefah(2013) on common bean. They found that,foliar applications with chitosan improved fruit quality of plants, Abdel-Mawgoud *et al*.(2010) on strawberry, found that total soluble solids showed tendency to increase in response to chitosan application. In addition, Shehata *et al*.(2012) reported that, foliar application of chitosan at rates of 4ml/l gave the highest contents of P in cucumber fruits plants. On the other hand, on strawberry, El-Miniawy *et al*.(2013) found that there was no significant effect for the tested treatments on most of fruit quality characters,the most effective treatment in fruit quality was found to be 5.0 ml/l chitosan.

Effect of the interaction

In the current results, the interaction between N fertilization and spraying with chitosan was found to have a significant effect on fruit quality except for T.S.S.% and K content in summer squash fruits (Table 6). In general, the interaction between N at 75 kg/feddan and 0.00g/l (control) chitosan gave the highest values of Fe, Zn, B, Mn and Cu contents in fruits. While, there were no significant differences with the interaction between N at 75 kg/feddan and chitosan at 0.00 (control) or 0.05g/l with respect to Cu content in fruits. Whereas the interaction between N at 75 kg/feddan and 0.10 g/l chitosan gave the highest values of N and P contents in fruits with no significant differences with the interaction between N at 60 or 75 kg/feddan and chitosan at 0.10 g/l with respect to P content in fruits.

In this respect, Shaheen *et al*.(2014) on potatoes, found that the highest nutritional values were obtained by spraying chitosan at 5% with the inorganic NPK fertilizer. In addition,El-Tanahy *et al*.(2012) on cowpea, reported that the best effect on seeds quality (N and P) was obtained by using the highest concentration of chitosan (5%) with the application of the inorganic fertilizer parameters.

Table 6: Effect of interaction between nitrogen rates and chitosan on fruit quality of summer squash during 2013/2014 season.

Treatments		T.S.S%	Macro nutrients (%)			Micro nutrients (ppm)				
			N	P	K	Fe	Zn	Cu	Mn	B
N rates (kg/feddan)	Chitosan (g/l.)									
45	0 .00	3.33 b	2.60. d	0.29 d	2.50 a	61.32 d	40.08 b	9.76 cd	76.88 i	36.68 e
	0.05	3.83 ab	2.67 d	0.32 bcd	2.80 a	55.49 e	39.24 c	10.19 bc	80.55 g	40.19 b
	0.10	4.50 a	3.19 bc	0.37 abc	2.84 a	62.09 c	38.97 cd	8.79 e	94.06 b	35.59 h
60	0 .00	4.00 ab	2.89 bcd	0.30 cd	2.61 a	62.25 c	37.11 e	10.23 b	91.78 d	36.44 f
	0.05	4.00 ab	2.87 cd	0.34 bcd	2.87 a	63.17 b	32.89 g	9.58 d	78.54 h	36.14 g
	0.10	4.50 a	3.20 bc	0.39 ab	2.78 a	54.97 f	35.46 f	8.64 e	88.31 f	38.50 d
75	0 .00	4.16 ab	2.90 bcd	0.31 cd	2.83 a	64.02 a	41.02 a	11.08 a	94.77 a	40.25 a
	0.05	4.16 ab	3.24 b	0.36 abcd	2.88 a	61.09 d	38.65 d	11.05 a	93.16 c	36.67 e
	0.10	4.66 a	4.00 a	0.43 a	2.50 a	55.47 e	36.78 e	9.79 bcd	91.27 e	38.53 c

Values having the same alphabetical letter(s) in each column did not significantly different according to L.S.D at 0.05 of probability.

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